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# FINAL REPORT

Rice Quality Classification Using Deep Learning

**Submitted by**

Sheraz Raza

2019-GCUF-084520

Wahab Ali

2019-GCUF-063393

**Department of Computer Science**

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# CERTIFICATE

This is to certify that bearing ***Sheraz Raza*** Registration No. ***Registration# 2019-GCUF-084520*** and ***Wahab Ali*** Registration No. ***Registration# 2019-GCUF-063393*** has completed the final project titled as ***"Rice Quality Classification Using Deep Learning"*** at the **Department of Computer Science**, **Govt. Graduate College Samanabad Faisalabad**, to fulfill the partial requirement for the degree of **BS - CS**.

## Supervisor

**Supervisor Name: Mam Somia** **Signature: _____________**

## Internal Panel

**Member 1: Sir Rafique** **Signature: ____________**

**Member 2: Mam Sania Anwar** **Signature: ____________**

**Member 3: Mam Mamoona** **Signature: ____________**

## Project Coordinator

## Head of Department

## Principal

# DECLARATION

The work reported in this project was carried by me under the supervision of **Somia Ali at Government Graduate College Samanabad Faisalabad.**

I hereby declare that this project and the contents of project are the product of my own research and no part has been copied from any other written or published source (accept the references, standard mathematical or genetics models / equation / formulas / protocol etc.).I further declare that this work has not been submitted for award of any other degree diploma. The institution may take action if the provided information is found inaccurate at any stage.

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|---|---|---|
| **Name** | **:** | **Sheraz Raza** |
| **Registration no** | | **2019-GCUF-084520** |
| **Name** | | **Wahab Ali** |
| **Registration no** | **:** | **2019-GCUF-063393** |

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# Abstract

The "Rice Quality Classification" project aims to develop an efficient and automated system for identifying the category of rice seeds based on their sizes. In the rice industry, rice seeds are grown in various forms, and different sizes indicate distinct categories. The purpose of this project is to create a robust deep learning model using the YOLOv8 architecture to accurately classify rice seeds into their respective categories. To achieve this, a diverse and representative dataset of rice seeds containing samples from each of the five classes based on their sizes is curated and used for training the YOLOv8 model. The model is fine-tuned to ensure optimal classification performance. The project also involves the development of a user-friendly mobile app and web application, enabling users to capture or upload images of rice seeds for real-time classification. The system's success is evaluated through rigorous performance testing, aiming to achieve high accuracy and reliability in rice seed classification. The integration of the YOLOv8 model into the mobile app and web application empowers users in the rice industry to make informed decisions based on the identified rice seed category

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# Chapter 1: Introduction

## 1.1 Project Purpose and Significance

The project "Rice Quality Classification" aims to address the need for an efficient and accurate system to classify rice seeds into different categories based on their sizes. The purpose of this project is to provide a user-friendly solution for the rice industry to identify and categorize rice seeds in real-time using a mobile app or web application. By automating the seed classification process, the project seeks to streamline the rice production and distribution workflow, leading to improved efficiency and productivity.

### 1.1.1 Significance of the Project

The significance of the "Rice Quality Classification" project lies in its potential to bring about transformative changes in the rice industry. The key significance points are:

1. Improved Efficiency: The automated seed classification system eliminates the need for manual classification, saving valuable time and effort for farmers, millers, and distributors. This efficiency gain can lead to increased overall productivity.
2. Enhanced Quality Control: Accurate classification of rice seeds ensures that each seed is categorized correctly based on its size, leading to improved quality control in rice production and distribution.
3. Real-Time Classification: The mobile app and web application allow users to obtain instant classification results, enabling quick decision-making during seed selection and distribution.
4. Scalability: The project's architecture and design enable it to scale efficiently, accommodating a growing volume of data and users as the rice industry expands.
5. Technological Advancement: Leveraging deep learning techniques, such as the YOLOv8 model, showcases the application of cutting-edge technology in the agricultural sector, promoting technological advancement and adoption.
6. Accessibility: With the integration of the classification system into a mobile app and web application, users can access the technology from anywhere with internet connectivity, making it accessible to a wider audience.

### 1.1.2 Project Purpose

The primary purpose of the "Rice Quality Classification" project is to provide a robust and accurate system that can classify rice seeds into five distinct categories based on their sizes. The purpose encompasses the following goals:

1. Develop a Deep Learning Model: The project aims to implement the YOLOv8 deep learning model and fine-tune it using a diverse and curated dataset of rice seed images.
2. Real-Time Classification: The system should provide real-time classification results to users through a user-friendly mobile app and web application.
3. Enhanced Accuracy: The deep learning model's fine-tuning and validation process aim to achieve a high level of accuracy in seed classification.
4. User-Friendly Interface: The mobile app and web application should be intuitive and easy to navigate, allowing users to interact with the system seamlessly.
5. Scalability and Adaptability: The project should be designed to accommodate future expansions and updates, enabling the incorporation of additional features and improvements.
6. Integration with Industry Practices: The project seeks to align with existing rice industry practices and workflows, ensuring that it can be seamlessly integrated into the existing ecosystem.

## 1.1 Aim and Objectives

### 1.2.1 Aim of the Project

The aim of the "Rice Quality Classification" project is to develop an intelligent and automated system that can accurately classify rice seeds into distinct categories based on their sizes. By leveraging state-of-the-art deep learning techniques, the project seeks to provide a reliable and efficient solution for the rice industry to identify and segregate rice seeds effectively. The ultimate goal is to enhance the productivity, efficiency, and quality control in rice production and distribution processes.

### 1.2.2 Objectives

The specific objectives of the "Rice Quality Classification" project include:

1. Implement YOLOv8 Deep Learning Model: Develop and fine-tune the YOLOv8 deep learning model using a large and diverse dataset of rice seed images to enable accurate classification.
2. Dataset Collection and Curation: Gather a comprehensive dataset of rice seed images from different sources, ensuring it represents the variability in rice seed sizes across various classes.
3. Mobile App and Web Application Development: Create an intuitive and user-friendly mobile app and web application that allows users to input images of rice seeds and receive real-time classification results.
4. Achieve High Classification Accuracy: Conduct extensive model training, validation, and testing to achieve a high level of accuracy in classifying rice seeds into their respective categories.
5. Real-Time Processing: Optimize the deep learning model to perform classification tasks in real-time, ensuring swift results to users.

## 1.3 Background and Problem Definition

### 1.3.1 Background

Rice is one of the most important staple foods in the world, providing sustenance to a significant portion of the global population. With the increasing demand for high-quality rice, farmers and rice millers face the challenge of efficiently sorting and classifying rice seeds based on their sizes. Proper classification is essential for various purposes, including determining the market value, optimizing packaging, and ensuring consistent quality in the rice supply chain.

### 1.3.2 Problem Definition

The "Rice Quality Classification" project addresses the challenge of automating the rice seed classification process using modern deep learning techniques. The specific problem is to develop an AI-powered system capable of classifying rice seeds into distinct categories based on their sizes. The system should be able to handle a variety of rice seed images and accurately assign them to the corresponding classes.

The key problems to solve are as follows:

1. Image Classification: Developing a deep learning model that can effectively recognize and classify rice seed images into predefined classes based on their size categories.
2. Accuracy and Reliability: Ensuring that the classification system achieves a high level of accuracy and reliability to minimize misclassification errors, thereby providing dependable results.
3. Real-Time Processing: Designing the system to process images in real-time, enabling quick and efficient classification without significant delays.
4. User-Friendly Interface: Creating an intuitive user interface for the mobile app and web application, allowing users to easily interact with the system and obtain classification results effortlessly.
5. Scalability: Designing the system to handle a large number of users and images without compromising performance, making it suitable for both small-scale and large-scale rice production environments.

## 1.4 Project Modules

The Rice Quality Classification project is designed with various modules, each serving specific functionalities and tasks. These modules work collaboratively to accomplish the project's main objective of accurately identifying the category of rice seeds. Below are the key project modules:

1. Image Selection Module:
    - The Image Selection Module handles the functionality of allowing users to select images from their device's gallery.
    - Users can choose relevant images containing rice seeds for classification.
    - The module ensures proper image handling and preprocessing before passing the selected images to the classification module.
2. Pretrained YOLOv8 Model Module:
    - The Pretrained YOLOv8 Model Module is the core of the classification system, incorporating a fine-tuned YOLOv8 deep learning model.

- The YOLOv8 model has been trained on a custom dataset to achieve high accuracy in classifying the rice seeds into distinct categories.

3. Classification Module:
    - The Classification Module receives preprocessed images from the Image Selection Module and feeds them to the Pretrained YOLOv8 Model Module for classification.
    - It interprets the model's predictions and determines the class to which the rice seed belongs.
4. User Interface Module:
    - The User Interface (UI) module creates an interactive and user-friendly interface for the application.
    - It displays the selected image, classification results, and any relevant information to the user.
5. Integration Module (Android App):
    - The Integration Module facilitates the seamless integration of the Pretrained YOLOv8 Model with the Android application.
    - It ensures that the model works seamlessly within the app, allowing users to classify rice seeds on their Android devices.
6. Login Module
    - Login(Email and Password)
    - SignUp(First Name, Last Name, Email and Password)
    - Reset Password if forget your password.
7. Offline Support Module:
    - The Offline Support Module enables the application to function without an active internet connection.
    - It allows users to perform rice seed classification even in areas with limited or no internet access.

# Chapter 2: Technological Framework

## 2.1 Related Works and Existing Solutions

### 2.1.1 Related Works

In recent years, the field of computer vision and deep learning has witnessed significant advancements in image classification tasks. Researchers and developers have explored various techniques and methodologies to tackle similar image classification problems in different domains.

Several studies have focused on applying deep learning models, such as Convolutional Neural Networks (CNNs), for image classification tasks. CNNs have proven to be highly effective in learning meaningful features from images, making them well-suited for tasks like rice seed classification. These studies have demonstrated promising results in classifying objects and patterns in images accurately.

Additionally, advancements in object detection models, such as YOLO (You Only Look Once), have paved the way for more sophisticated and efficient solutions in image classification tasks. YOLO is known for its real-time object detection capabilities, which could be adapted to classify rice seeds accurately and efficiently.

### 2.1.2 Existing Solutions

While there are several studies and works related to image classification using deep learning techniques, specific existing solutions for rice quality classification are limited. Most traditional rice classification methods rely on manual sorting and basic image processing techniques, which may lack the accuracy and efficiency desired for large-scale rice production.

The "Rice Quality Classification" project aims to build upon the existing works in image classification and tailor them to the specific domain of rice seed classification. By leveraging state-of-the-art deep learning models, transfer learning, and efficient object detection techniques, this project intends to develop a robust and scalable solution that can accurately and rapidly classify rice seeds based on their size categories. Through this approach, the system will overcome the limitations of traditional methods and provide an innovative and reliable solution to the rice industry's classification needs.

## 2.2 Comparison of YOLOv8 with Other Deep Learning Models

In the realm of deep learning and computer vision, various models have been proposed to tackle object detection and image classification tasks. One of the prominent models used for real-time object detection is YOLO (You Only Look Once), which has undergone several iterations, with YOLOv8 being one of the latest versions. In this section, we compare YOLOv8 with other deep learning models to highlight its strengths and advantages for rice quality classification.

1. YOLOv8 (You Only Look Once version 8):
    - YOLOv8 is an advanced version of the YOLO family of models, known for its real-time object detection capabilities.
    - It employs a single-stage object detection approach, making it highly efficient and suitable for real-time applications.
    - YOLOv8 utilizes Darknet, a deep neural network framework, as its backbone to learn feature representations from images effectively.
2. Faster R-CNN (Region-based Convolutional Neural Networks):
    - Faster R-CNN is a two-stage object detection model that first proposes regions of interest and then classifies objects within those regions.
    - While Faster R-CNN can achieve competitive accuracy, its two-stage design makes it computationally more demanding compared to YOLOv8.
3. SSD (Single Shot Multibox Detector):
    - SSD is a single-stage object detection model that utilizes multi-scale feature maps to predict object bounding boxes and class probabilities.
    - However, SSD's accuracy might be lower compared to two-stage models like Faster R-CNN and YOLOv8, especially for small objects or densely packed scenes.
4. RetinaNet:

- RetinaNet is a one-stage object detection model that addresses the imbalance between foreground and background classes by employing a focal loss function.
- RetinaNet is particularly effective when dealing with datasets with imbalanced class distributions.

## 2.3 Existing Tools & Technologies

- Google Collab
- TensorFlow Framework
- Android Studio
- Firebase Database
- Android Studio
- Languages

### 2.3.1 Google Collaboratory

Google Colaboratory, commonly known as Google Colab, is a cloud-based platform provided by Google that allows users to run and execute Python code in a Jupyter Notebook environment. It is an ideal choice for machine learning and deep learning tasks as it offers free access to powerful GPUs and TPUs (Tensor Processing Units), significantly accelerating the training process.

In the context of the Rice Quality Classification project, Google Colab played a crucial role in various aspects:

1. Dataset Preparation: Google Colab was used to upload the rice seed dataset, which was then unzipped and preprocessed to prepare it for training. The platform's ability to access Google Drive seamlessly made it convenient to store and manage the large dataset.

2. Importing Ultralytics YOLOv8 Model: Ultralytics is a popular open-source repository that provides implementations of various deep learning models, including YOLOv8. Google Colab allowed for easy integration with Ultralytics,

enabling the project to utilize the advanced YOLOv8 architecture for seed classification.

3. Training and Fine-tuning: The training of the YOLOv8 model involved multiple iterations of fine-tuning on the custom rice seed dataset. Google Colab's access to powerful GPUs significantly accelerated the training process, reducing the time required to achieve high accuracy.
4. Hyperparameter Tuning: During the training process, various hyperparameters, such as learning rate, batch size, and number of epochs, were tuned to optimize the model's performance. Google Colab's interactive and collaborative environment facilitated experimenting with different hyperparameter settings and tracking the training progress.
5. Model Evaluation: After training, the model's performance was evaluated on a separate test dataset to assess its accuracy and generalization capabilities. Google Colab provided the necessary resources to efficiently execute the evaluation process.

### 2.3.1 TensorFlow Framework

TensorFlow is an open-source machine learning framework developed by Google that is widely used for building and training deep learning models. It provides a comprehensive set of tools and libraries for creating neural networks, performing numerical computations, and optimizing model performance.

In the context of the Rice Quality Classification project, TensorFlow played a crucial role in two main aspects:

1. Model Conversion to TFLite: After training and fine-tuning the YOLOv8 model on the custom rice seed dataset, the next step was to deploy the model on a mobile device, specifically an Android application. However, the original model was in the PyTorch (.pt) format, which is not directly compatible with Android devices. TensorFlow provided the necessary tools and utilities to convert the PyTorch model into the TensorFlow Lite (TFLite) format, which is optimized for mobile and edge devices.

2. Model Testing and Validation: Once the TFLite model was generated, it was crucial to validate its functionality and accuracy before integrating it into the Android application. TensorFlow's extensive documentation and community support allowed for easy implementation of the TFLite model in Python, enabling testing on sample rice seed images. This step ensured that the model's performance was retained after conversion and that it correctly classified rice seeds into their respective categories.

### 2.3.1 Android Studio

In the context of the Rice Quality Classification project, Android Studio played a central role in creating the mobile application that allows users to classify rice seeds using the YOLOv8 model. Here's how Android Studio was used in the project:

1. App Development: Android Studio provided a user-friendly and efficient environment for writing the Java code that defines the functionality and user interface of the mobile app. The Android app consisted of various screens, such as the home screen, image selection screen, and result screen, which were designed and implemented using Android Studio's layout editor and Java code.

2. Model Integration: Android Studio allowed for seamless integration of the TensorFlow Lite (TFLite) model generated from the YOLOv8 model into the mobile app. The TFLite model was loaded into the Android app, and the app could pass images to the model for inference to predict the rice seed category.

3. User Interface: Android Studio's layout editor enabled the design of an intuitive and user-friendly interface for the app. The app's user interface included features such as buttons, image views, and result displays, all of which were visually laid out using Android Studio's drag-and-drop editor.

### 2.3.1 Firebase Database

Firebase Database is a cloud-hosted NoSQL database provided by Google as part of the Firebase platform. It offers real-time data synchronization and storage capabilities, making it an excellent choice for mobile and web applications that require efficient data management and collaboration among users.

In the context of the Rice Quality Classification project, Firebase Database played a crucial role in handling user authentication (sign in and sign up) and storing data related to the app. Here's how Firebase Database was utilized in the project:

1. User Authentication: Firebase Authentication provided a secure and reliable way to handle user sign-in and sign-up functionalities. Users could create accounts and log in using their email and password or other supported authentication methods like Google Sign-In. Firebase Authentication handled the user identity securely and allowed for authentication token management.

### 2.3.1 Languages used

1. **Python:**

Python is a versatile and widely-used programming language that was employed for various tasks in your Rice Quality Classification project. Here's how Python was utilized:

- Model Training: Python is a popular choice for training machine learning and deep learning models due to its extensive libraries and frameworks. In your project, Python, along with libraries like PyTorch and Ultralytics, was used to implement and train the YOLOv8 model on the custom dataset of rice images.
- Model Conversion: Python, along with the TensorFlow library, was employed to convert the trained YOLOv8 model from the .pt format to the .tflite format. TensorFlow provides tools and utilities for converting models to TensorFlow Lite format, which can be deployed on mobile devices like Android.

2. **Java:**

Java is a widely-used, object-oriented programming language known for its platform independence. In your project, Java was utilized in the Android Studio environment for building the mobile app. Here's how Java was used:

- Android App Development: Java is the primary language for Android app development. In Android Studio, you wrote Java code to create the user interface, handle app logic, and integrate the TensorFlow Lite model for rice quality classification. Java's object-oriented nature and robust standard library made it suitable for developing the app's functionality.

# Chapter 3: SYSTEM REQUIREMENT ANYLYSIS

In this chapter, we will delve into the various aspects of the system requirement analysis for the Rice Quality Classification project. This analysis is crucial as it helps identify and define the functional and non-functional requirements that the system must meet to achieve its intended goals successfully. Additionally, the hardware and software requirements needed to support the system will be outlined. Let's explore each section in detail:

## 3.1 Functional Requirements:

### Table 3.1: List of Requirements

| **Requirement No.** | **Requirement name** | **Source person** |
|---|---|---|
| **Req-01** | Login | Admin and User |
| **Req-02** | Logout | Admin and User |
| **Req-03** | Sign up | Admin and User |
| **Req-04** | Home Page | Admin and User |
| **Req-05** | Feedback Submit | Admin and Staff |
| **Req-06** | Read Policies and Get Help | Admin and User |
| **Req-07** | Firebase Database | Admin |

## 3.2 System Non-Functional Requirements

System non-functional requirements define the quality attributes and constraints that the Rice Quality Classification system must adhere to. These requirements focus on aspects such as performance, maintainability, security, and software quality. Let's outline the non-functional requirements for the system:

1. Maintainability:
    - The system's codebase should be well-organized and modular to facilitate easy maintenance and future updates.
2. Performance:
    - The image classification process should be efficient, providing quick and accurate predictions to users.
3. Security:
    - User data, including login credentials and feedback, should be stored securely in the Firebase database, using encryption and access controls.
4. Software Quality:
    - The system should undergo rigorous testing to ensure its functionality, accuracy, and stability.
5. Scalability:
    - The system should be designed to handle potential future growth in user base and data volume without significant performance degradation.
6. Usability:
    - The user interface should be intuitive and user-friendly, ensuring that users can easily navigate and interact with the app.
7. Compatibility:
    - The Android app should be compatible with a wide range of Android devices and operating system versions.

## 3.3 Hardware & Software Requirements

**Hardware Requirements:**

- Android Device: The app should be compatible with a wide range of Android devices, including smartphones and tablets.
- RAM: At least 1 GB RAM to ensure smooth performance of the app.

## 3.4 Methodology

### 3.4.1 Spiral Mode

The Spiral Model is a software development life cycle model that combines iterative development with elements of the waterfall model. It was first introduced by Barry Boehm in 1986. The Spiral Model is particularly well-suited for large and complex projects where uncertainty and risks are high. It is an adaptable and flexible model that allows for incremental development and frequent feedback loops.

Here's a brief explanation of the key phases in the Spiral Model:

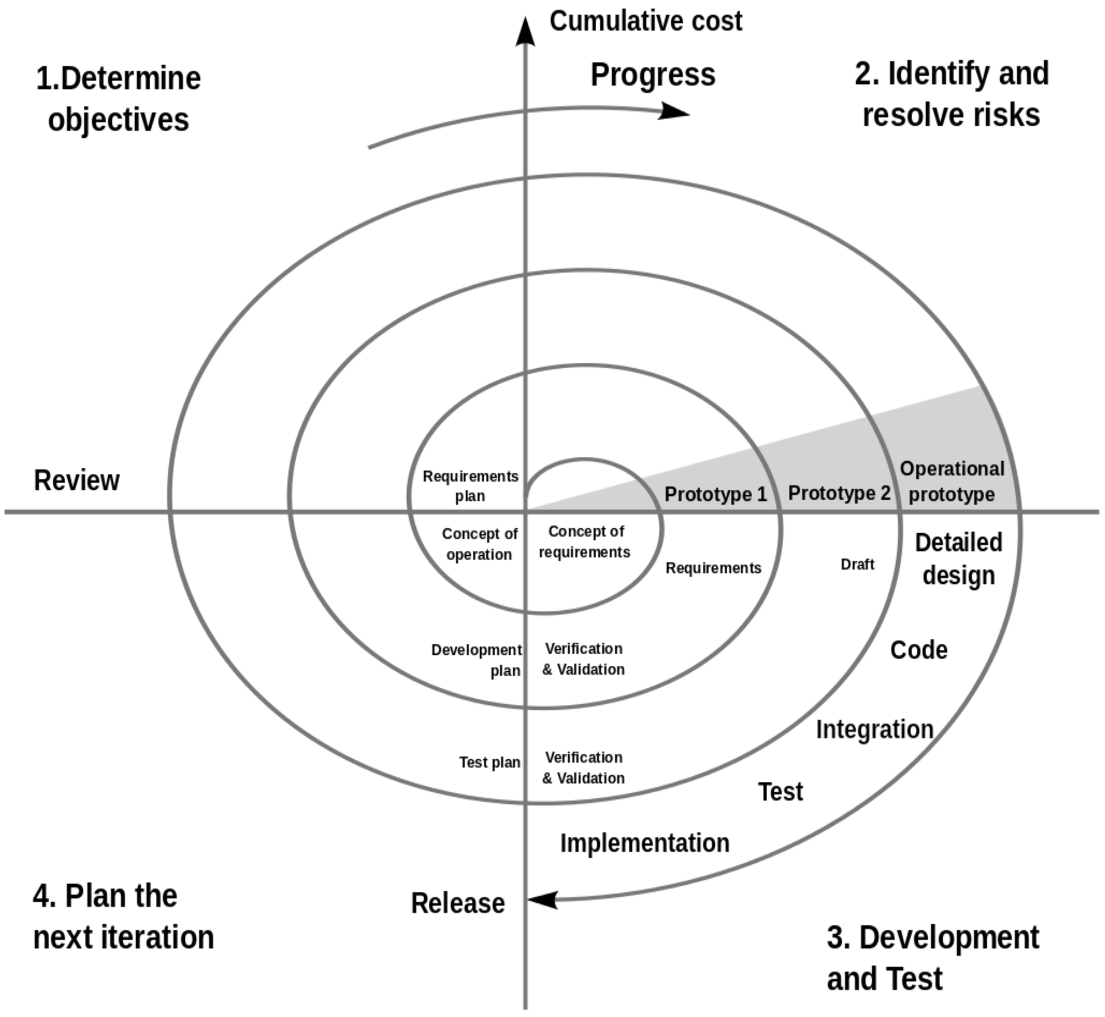


*Figure 1 Figure of Spiral Model*

1. **Planning Phase:** In this phase, the objectives, requirements, and constraints of the project are defined.
2. **Risk Analysis:** The Spiral Model places significant emphasis on risk analysis. During this phase, project risks are assessed, and strategies are developed to mitigate or manage those risks.
3. **Engineering Phase:** This is the phase where the actual development of the software takes place.
4. **Evaluation Phase:** At the end of each iteration, a review is conducted to evaluate the progress of the project.
5. **Next Iteration Planning:** Based on the evaluation results and feedback, the next iteration is planned.

## 3.5 Data Collection

Data collection and preprocessing play a crucial role in the success of any machine learning project, including rice quality classification using the YOLOv8 model. In this chapter, we outline the methodology employed for collecting and preparing the dataset, which forms the foundation for training and evaluating the model.

### 3.5.1 Data Collection:

- The first step in the data collection process is to acquire a diverse and representative dataset of rice seed images. The dataset should cover different rice varieties, sizes, and quality grades that are commonly encountered in the industry.

### 3.5.2 Data Preprocessing:

- Before feeding the images into the YOLOv8 model, certain preprocessing steps are necessary to enhance the model's performance and generalization capabilities.
- Image resizing: The rice seed images may have varying resolutions and aspect ratios. Resizing the images to a consistent resolution ensures uniformity and reduces the computational burden during training.

## 3.6 YOLOv8 Model Overview and Architecture

In this section, we provide an overview of the YOLOv8 model, which stands for "You Only Look Once version 8." YOLOv8 is a state-of-the-art deep learning model used for real-time object detection and classification tasks. It has been widely adopted due to its remarkable accuracy and efficiency, making it well-suited for our rice quality classification project.

### 3.6.1 YOLOv8 Model Overview:

- YOLOv8 is based on the single-stage object detection approach, where it directly predicts bounding boxes and class probabilities for objects present in the input image.
- Unlike traditional two-stage detection models, YOLOv8 performs object localization and classification simultaneously, making it much faster and more efficient for real-time applications.

### 3.6.2 YOLOv8 Model Architecture:

- The architecture of YOLOv8 is composed of multiple convolutional layers, downsampling layers, and fully connected layers.
- The network consists of a backbone, which is a series of stacked convolutional blocks responsible for feature extraction from the input image.
- Following the backbone, there are detection heads, which predict bounding box coordinates and class probabilities for rice seeds in different size categories.
- YOLOv8 utilizes Darknet-53 as its backbone, which is a deep CNN architecture with 53 layers, making it capable of learning intricate patterns and representations.

## 3.7 Fine-tuning and Hyperparameter Tuning

In this section, we discuss the crucial steps of fine-tuning the YOLOv8 model and the process of hyperparameter tuning. Fine-tuning is a vital technique used to adapt a pre-trained model on a large dataset to a specific task, which, in our case, is rice quality classification. Additionally, hyperparameter tuning involves finding the optimal values for various parameters that significantly impact the model's performance.

### 3.7.1 Fine-tuning the YOLOv8 Model:

- We begin by using a pre-trained YOLOv8 model that has been trained on a large-scale dataset containing diverse objects from various categories.
- To make the model specialize in rice quality classification, we perform fine-tuning using our rice dataset, which includes images of rice seeds categorized into five different size classes.

### 3.7.2 Hyperparameter Tuning:

- Hyperparameters are adjustable parameters that are set before training the model and significantly affect its performance.
- Examples of hyperparameters include learning rate, batch size, number of epochs, and weight decay.

## 3.8 Evaluation Metrics

Evaluation metrics are essential in assessing the performance and effectiveness of the rice quality classification model. These metrics provide quantitative measurements that indicate how well the model is performing in categorizing rice seeds into their respective size classes. The following evaluation metrics are commonly used in the context of multi-class classification tasks:

1. Accuracy:
    - Accuracy is one of the most straightforward metrics and represents the ratio of correctly classified rice seeds to the total number of rice seeds in the dataset. It is defined as follows: Accuracy = (Number of Correctly Classified Samples) / (Total Number of Samples)
2. Precision, Recall, and F1-Score:
    - Precision, Recall, and F1-Score are metrics commonly used in multi-class classification tasks to assess the model's performance for each class individually.
    - F1-Score is the harmonic mean of precision and recall, providing a balanced evaluation metric that considers both false positives and false negatives

# Chapter 4: System Design

## 4.1 System design

System Design is the process of designing the elements of a system such as the architecture, modules and components, the different interfaces of those components and the data that goes through that system.

4.2 System Analysis

System Analysis is the process that decomposes a system into its component pieces for the purpose of defining how well those components interact to accomplish the set requirements.

The purpose of the System Design process is to provide sufficient detailed data and information about the system and its system elements to enable the implementation consistent with architectural entities as defined in models and views of the system architecture.

## 4.3 Elements of a System

- **Architecture** - This is the conceptual model that defines the structure, behavior and more views of a system. We can use flowcharts to represent and illustrate the architecture.
- **Modules -** This are components that handle one specific tasks in a system. A combination of the modules make up the system.
- **Components -** This provides a particular function or group of related functions. They are made up of modules.
- **Interfaces -** This is the shared boundary across which the components of the system exchange information and relate.
- **Data -** This the management of the information and data flow.

## 4.4 Major Tasks Performed During the System Design Process

### 4.4.1 Initialize design definition

- Plan for and identify the technologies that will compose and implement the systems elements and their physical interfaces.
- Determine which technologies and system elements have a risk to become obsolete, or evolve during the operation stage of the system. Plan for their potential replacement.
- Document the design definition strategy, including the need for and requirements of any enabling systems, products, or services to perform the design.

### 4.4.2 Establish design characteristics

- Define the design characteristics relating to the architectural characteristics and check that they are implementable.
- Define the interfaces that were not defined by the System Architecture process or that need to be refined as the design details evolve.
- Define and document the design characteristics of each system element2.

### 4.4.3 Assess alternatives for obtaining system elements

- Assess the design options
- Select the most appropriate alternatives.
- If the decision is made to develop the system element, rest of the design definition process and the implementation process are used. If the decision is to buy or reuse a system element, the acquisition process may be used to obtain the system element.

## 4.5 Use Case Model

A Use Case Model describes the proposed functionality of new system. A Use Case represents a discrete unit of interaction between a user (human or machine) and the system.

**List of Actors**

- *User*; this person Login, Sign Up, Logout, Do predictions and give feedback.
- *Administration*; this person manages the whole system.

**List of Use Cases**

- *Login Catalog;* customer read superficially a list of things.
- *Signup Catalog;* customer finds the desired item.
- *Logout Account;* customer creates account to buy item.
- *Select image;* customer login to the site to buy item.
- *Predict Image;* customer manages the selected item.
- *Give Feedback;* customer selects the desired item.
- *Read Policies;* customer can easily manage his/her cart.
- *Get Help;* customer adds item to cart.

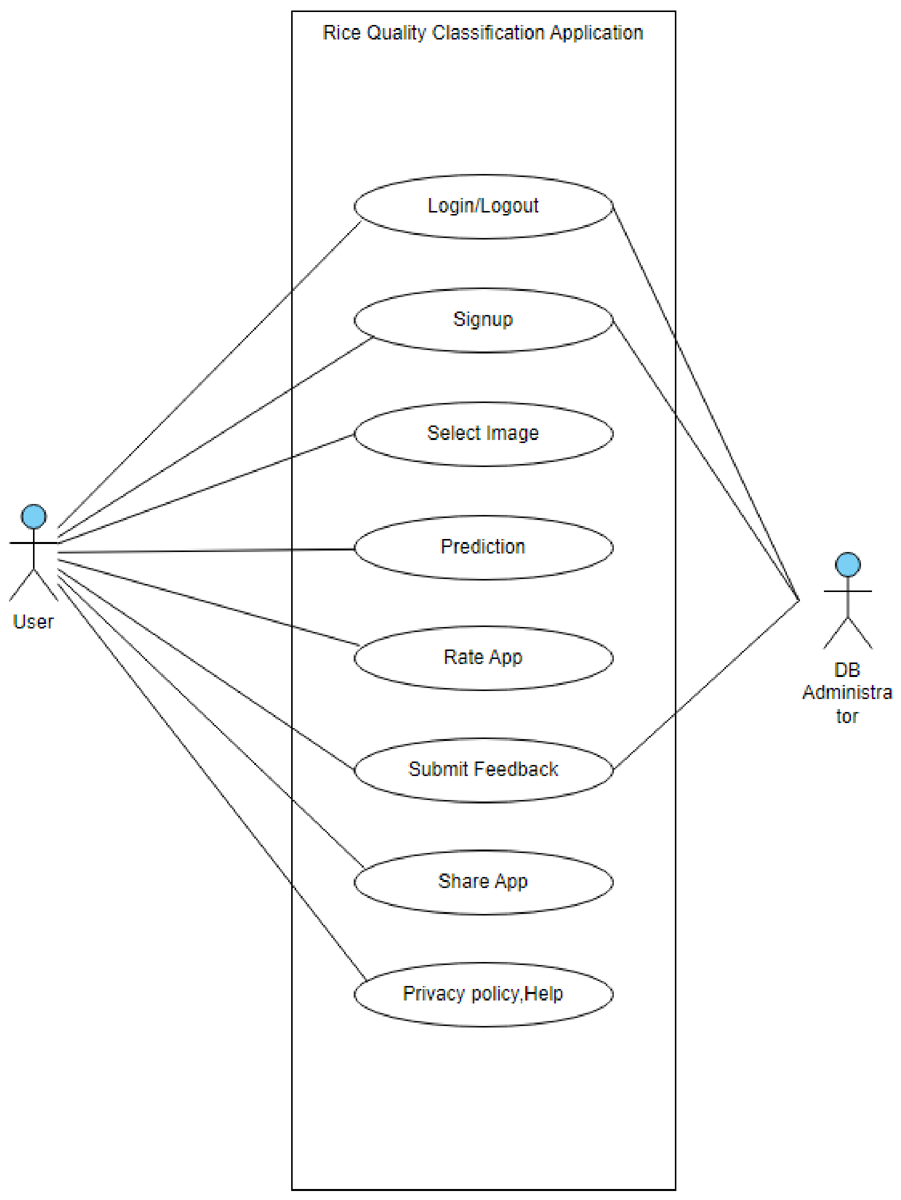


*Figure 2 Fully Dressed Use Case*

### 4.5.1 Fully dressed Format of Use Case

**Login Property:**

User can log in by entering email and password.

*Table 1: login Property*

| | | | |
|---|---|---|---|
| **Section: Main** | **UC-1** | | |
| *Name:* | ***Login*** | | |
| *Actors:* | *User* | | |
| *Purpose:* | *Login the user to do predictions.* | | |
| *Description:* | *User login to the account and select the image for prediction.* | | |
| *Cross References:* | *None* | | |
| **Pre-Conditions** | *Account must be created.* | | |
| **Successful Post-Conditions** | *User is login.* | | |
| **Failure Post-Conditions** | *User is not login.* | | |
| **Typical Course of Events** | | | |
| **Actor Action** | | **System Response** | |
| *1* | *Enters the email/password and click Login.* | *2* | *Logged.* |
| **Alternative Course** | | | |
| *Step-7.* | *Invalid user name or password.* | | |

**Sign Up Property:**

User can Sign Up in by entering email, password and other details.

*Table 2: Sign up Property*

| **Section: Main** | **UC-2** | | |
|---|---|---|---|
| *Name:* | ***Create account*** | | |
| *Actors:* | *User* | | |
| *Purpose:* | *To make user registered to do predictions.* | | |
| *Description:* | *An interface appears holding some blanks to make account for stgnup.* | | |
| *Cross References:* | *None* | | |
| **Pre-Conditions** | *None* | | |
| **Successful Post-Conditions** | *User's account is created.* | | |
| **Failure Post-Conditions** | *User account is not created.* | | |
| **Typical Course of Events** | | | |
| **Actor Action** | | **System Response** | |
| *1* | *Selects the option 'create account'* | *2* | *A new interface appear.* |
| *3* | *Fills the require information* | *4* | *Form is filled.* |
| *5* | *Clicks the 'Signup button.* | *6* | *Account is created.* |
| **Alternative Course** | | | |
| *Step 4* | *Account is not created.* | | |

**Select Image Property:**

User can select image for prediction.

*Table 3: Select image Property*

| | | | |
|---|---|---|---|
| **Section: Main** | **UC-3** | | |
| *Name:* | *Select image Homepage* | | |
| *Actors:* | *User* | | |
| *Purpose:* | *User select the image for the prediction.* | | |
| *Description:* | *User select the image from the gallery.* | | |
| *Cross References:* | *None* | | |
| **Pre-Conditions** | *Home page of the app before the image select.* | | |
| **Successful Post-Conditions** | *Image will be appear when image selected.* | | |
| **Failure Post-Conditions** | *Image did not appear.* | | |
| **Typical Course of Events** | | | |
| **Actor Action** | | **System Response** | |
| *1* | *Select button* | *2* | *Select one from the gallery* |
| **Alternative Course** | | | |
| *Step 3:* | *Image did not selected.* | | |

**Predict Image Property:**

User can click the predict to run the model.

*Table 4: Predict Image property*

| **Section: Main** | **UC-4** | | |
|---|---|---|---|
| *Name:* | *Predict image Homepage* | | |
| *Actors:* | *User* | | |
| *Purpose:* | *User click the predict button.* | | |
| *Description:* | *Model run in background the show Results.* | | |
| *Cross References:* | *None* | | |
| **Pre-Conditions** | *Home page of the app before the image select.* | | |
| **Successful Post-Conditions** | *Result will appear below.* | | |
| **Failure Post-Conditions** | *Result will not appear.* | | |
| **Typical Course of Events** | | | |
| **Actor Action** | | **System Response** | |
| *1* | *Predict button* | *2* | *Predict the image* |
| **Alternative Course** | | | |
| *Step 3:* | *Prediction error.* | | |

**View Privacy Policy Property:**

User can read the privacy and policy of the application.

*Table 5: View Privacy policy Property*

| | | | |
|---|---|---|---|
| **Section: Main** | **UC-5** | | |
| *Name:* | *View Policy page* | | |
| *Actors:* | *User* | | |
| *Purpose:* | *User should know what we accessing of his device.* | | |
| *Description:* | *User can view policies.* | | |
| *Cross References:* | *None* | | |
| **Pre-Conditions** | *Login.* | | |
| **Successful Post-Conditions** | *See the policies.* | | |
| **Failure Post-Conditions** | *Any error.* | | |
| **Typical Course of Events** | | | |
| **Actor Action** | | **System Response** | |
| *1* | *User read the policies.* | *2* | *Page appear.* |
| **Alternative Course** | | | |
| *Step 1:* | *Page don't appear.* | | |

**Feedback Property:**

User can send the feedback to the admin.

*Table 6: Feedback Property*

| **Section: Main** | **UC-6** | | |
|---|---|---|---|
| *Name:* | *Feedback Page* | | |
| *Actors:* | *User* | | |
| *Purpose:* | *Send feedback if facing any problem.,* | | |
| *Description:* | *If model not work good or application not working smoothly then user send feedback to  the admin.* | | |
| *Cross References:* | *None* | | |
| **Pre-Conditions** | *None* | | |
| **Successful Post-Conditions** | *See the feedback page.* | | |
| **Failure Post-Conditions** | *Can't see the feedback page.* | | |
| **Typical Course of Events** | | | |
| **Actor Action** | | **System Response** | |
| *1* | *User send the feedback.* | *2* | *Feedback submitted.* |
| *3* | *Submit button click.* | *4* | *Error occur.* |
| **Alternative Course** | | | |
| *Step 1:* | *Feedback not submit if internet is not available.* | | |

**Logout Property:**

User and admin can logout account.

*Table 7: Logout Property*

| **Section: Main** | **UC-7** | | |
|---|---|---|---|
| *Name:* | *Logout* | | |
| *Actors:* | *User and admin* | | |
| *Purpose:* | *Logout the account.* | | |
| *Description:* | *User and admin logout account when they need it.* | | |
| *Cross References:* | *None* | | |
| **Pre-Conditions** | *Login* | | |
| **Successful Post-Conditions** | *Logout page appear.* | | |
| **Failure Post-Conditions** | *Logout page not appear.* | | |
| **Typical Course of Events** | | | |
| **Actor Action** | | **System Response** | |
| *1* | *User and admin click the logout button.* | *2* | *Logout successfully* |
| **Alternative Course** | | | |
| *Step 1:* | *Logout failed if internet is not available.* | | |

## 4.6 Work Breakdown Structure

A work breakdown structure (WBS) is a visual, hierarchical and deliverable-oriented deconstruction of a project. It is a helpful diagram for project managers because it allows them to work backwards from the final deliverable of a project and identify all the activities needed to achieve a successful project.

All the steps of a project are outlined in the organizational chart of a work breakdown structure, which makes it an essential project management tool for planning and scheduling. The final deliverable rests on top of the diagram, and the levels below subdivide the project scope to indicate the phases, deliverables and tasks that are needed to complete the project.

At the top level is the project ultimate goal, the second level contains the project outcomes, the third level has the project outputs, and the fourth level with activities. Depending on the size and complexity of the project, the WBS may contain a fourth level that describe the tasks.

The WBS makes the deliverables more precise and concrete so that the project team knows exactly what has to be accomplished within each deliverable. This also allows for better estimating of cost, risk, and time because you can work from the smaller tasks back up to the level of the entire project.

There are five phase of this Project

1. Initiation
2. Design
3. Development
4. Testing
5. Implementation

**Initiation**

In this phase search is carried out then make a plane to develop the project. Also gather the requirements apply analysis process on it then finalize the project requirements.

**Design**

In this phase design is prepared .First of all Service Finder module is design then Service Provider module

After this tests the design, apply the changes and at the end design is ready.

**Module**

In this phase login/Sign Up for both user is developed then Service Finder module is developed then Service Provider module .At the end integrate the both module.

**Testing**

As the Application is developing the unit testing is applying step by step. At the end the whole application is test completely.

**Deployment**

At the end of application testing the application is deployed.

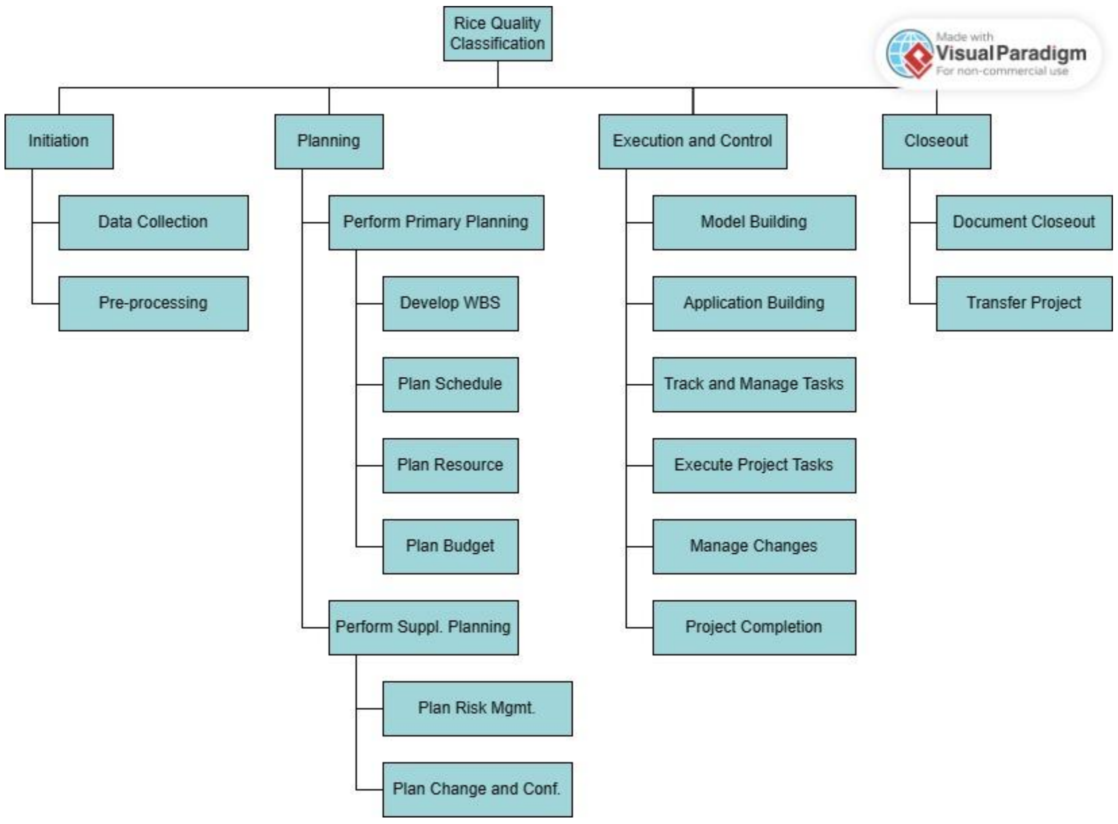


*Figure 3:**Work Breakdown Structure** (WBS)*

## 4.7 System sequence diagrams

A sequence diagram is another and in what order. It is a construct of a interactions arranged in time sequence. It depicts the objects and classes involved in the scenario and the sequence of messages exchanged between the objects needed to carry out the functionality of the scenario. Sequence diagrams are typically associated with use case realizations in the Logical View of the system under development. Sequence diagrams are sometimes called sequence diagram shows, objects that live simultaneously and the messages exchanged between them, in the order in which they occur. This allows the specification of simple runtime scenarios in a graphical manner. It portrays the items and classes required in the situation and the arrangement of messages traded between the articles expected to do the usefulness of the situation. Grouping charts are ordinarily connected with use case acknowledge in the Logical View of the framework a work in progress.

**Sequence Diagram or Rice Quality Classification**

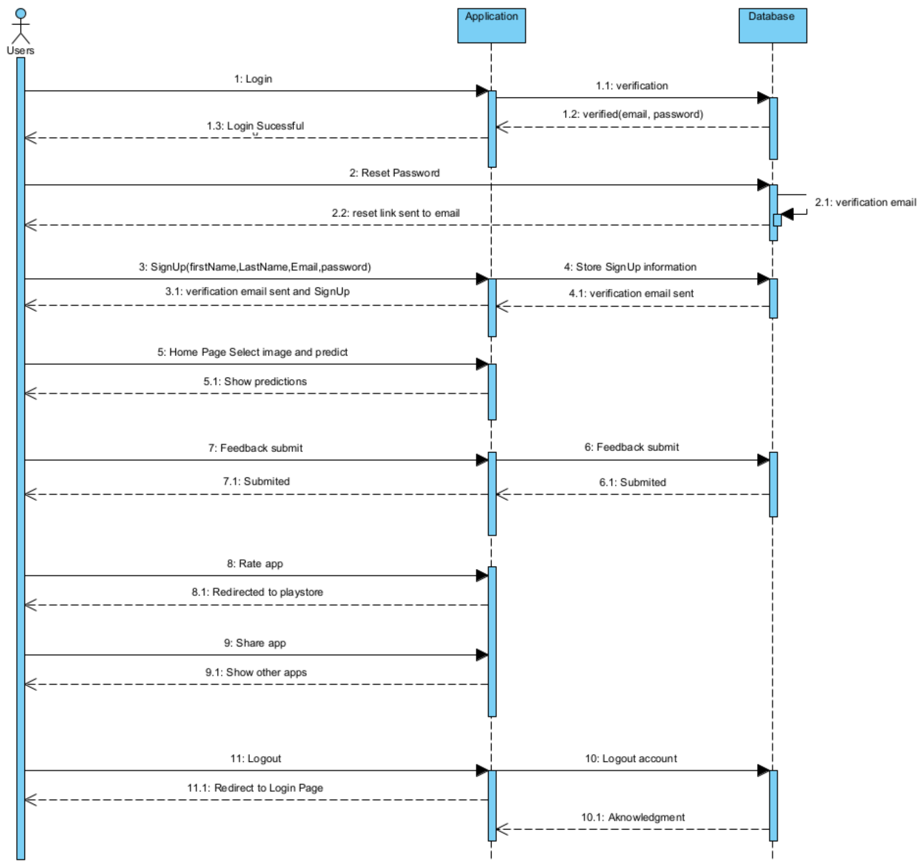

Users
Application
Database
1: Login
1.1: verification
1.2: verified(email, password)
1.3: Login Sucessful
2: Reset Password
2.1: verification email
2.2: reset link sent to email
3: SignUp(firstName,LastName,Email,password)
4: Store SignUp information
3.1: verification email sent and SignUp
4.1: verification email sent
5: Home Page Select image and predict
5.1: Show predictions
7: Feedback submit
6: Feedback submit
7.1: Submited
6.1: Submited
8: Rate app
8.1: Redirected to playstore
9: Share app
9.1: Show other apps
11: Logout
10: Logout account
11.1: Redirect to Login Page
10.1: Aknowledgment

*Figure 4: Sequence Diagram for **Rice Quality Classification***

## 4.8 Class Diagram

The class diagram is the main building block of object-oriented modeling. It is used for general conceptual modeling of the structure of the application, and for detailed modeling, translating the models into programming code. Class diagrams can also be used for data modeling.

Class diagram is a static diagram and it is used to model the static view of a system. Class diagrams are not only used to visualize the static view of the system but they are also used to construct the executable code for forward and reverse engineering of any system.

Class diagrams are the most important kind of UML diagram and are vitally important in software development. Class diagrams are the best way to illustrate a system's structure in a detailed way, showing its attributes, operations as well as its inter-relationships.

The Unified Modeling Language (UML) can help you model systems in various ways. One of the more popular types in UML is the class diagram. Popular among software engineers to document software architecture, class diagrams are a type of structure diagram because they describe what must be present in the system being modeled. No matter your level of familiarity with UML or class diagrams, our UML software is designed to be simple and easy to use.

UML was set up as a standardized model to describe an object-oriented programming approach. Since classes are the building block of objects, class diagrams are the building blocks of UML. The various components in a class diagram can represent the classes that will actually be programmed, the main objects, or the interactions between classes and objects.

The class shape itself consists of a rectangle with three rows. The top row contains the name of the class, the middle row contains the attributes of the class, and the bottom section expresses the methods or operations that the class may use. Classes and subclasses are grouped together to show the static relationship between each object.

The UML shape library in lucid chart can help you create nearly any custom class diagram using our UML diagram tool.

Class diagram shows a collection of classes, interfaces, associations, collaborations, and constraints. It is also known as a structural diagram.

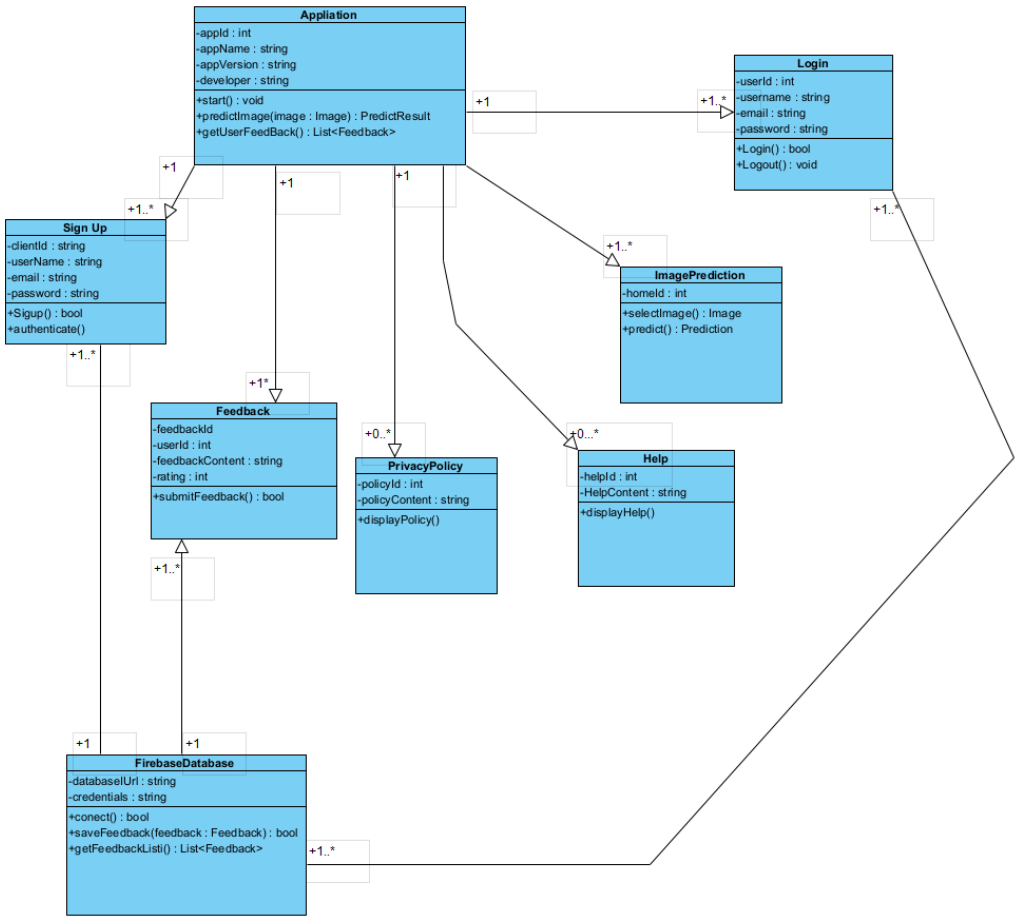


*Figure 5: CLASS DIAGRAM*

## 4.9 Data Flow Diagram

A data flow diagram is a graphical representation of the “flow” of data through an information system, modeling its process aspects.

A DFD shows what kind of information will be input to and output from the system, where the data will come from and go to, and where the data will be stored. It does not show information about the timing of process or information aboutwhether processes will operate in sequence or in paral

***DFD DIAGRAM OF Rice quality Classification***

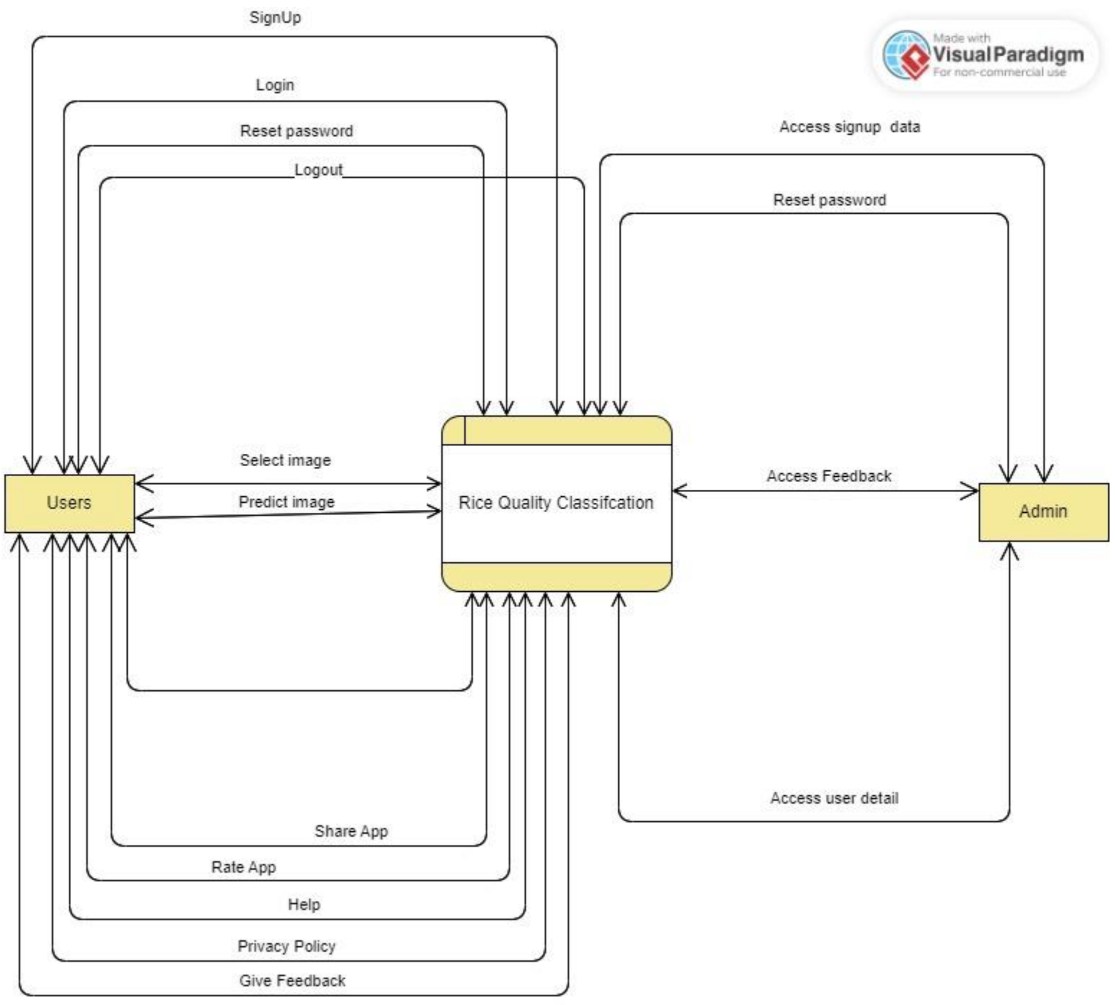


*Figure 6: DFD diagram for rice quality classification*

## 4.10 Test Cases

**Project Name: Rice Quality Classification**

### Test Case 1

**Test Case ID:** Fun_1 **Test Designed by:** Sheraz Raza

**Test Priority (Low/Medium/High):** Med **Test Designed date:** 18-7-23

**Module Name:** login screen

**Test Title:** Verify login with valid username and password

**Description:** Test the login page

**Test Executed by: Somia Ali**

**Test Execution date:** 19-7-23

**Pre-conditions:** User has valid username and password

**Dependencies:**

| Step | Test Steps | Test Data | Expected Result | Actual Result | Status (Pass/Fail) | Notes |
|---|---|---|---|---|---|---|
| 1 | Provide valid username | User= example@gmail.com | User should be able to login | User is navigated to | Pass | |
| 2 | Provide valid password | Password: 5333 | | dashboard with successful | | |
| 3 | Click on Login button | | | login | | |
| | | | | | | |

**Post-conditions:**

User is validated with database and successfully login to account. The account session details are logged in database.

**Project Name: Rice Quality Classification**

# Test Case 2

**Test Case ID:** Fun_2

**Test Designed by:** Sheraz Raza

**Test Priority (Low/Medium/High):** Med

**Test Designed date:** 22-7-23

**Module Name:** signup screen

**Test Executed by: Somia Ali**

**Test Title:** Signup new account

**Test Execution date:** 23-7-23

**Description:** Test the signup page

**Pre-conditions:** User has valid email for verification

**Dependencies:**

| Step | Test Steps | Test Data | Expected Result | Actual Result | Status (Pass/Fail) | Notes |
|---|---|---|---|---|---|---|
| 1 | Provide valid username | User= example@gmail.com | User data should be successfully stored. | User is navigated to | Pass | |
| 2 | Provide valid password | Password: 5333 | | Login page with successful | | |
| 3 | Provide First Name and Last Name | First Name: sheraz Last name: raza | | signup | | |
| 4 | Click signup button | | | | | |

**Post-conditions:**

User add the data and stored in database and signup .Account data store in database.

**Project Name: Rice Quality Classification**

# Test Case 3

**Test Case ID:** Fun_3

**Test Designed by:** Sheraz Raza

**Test Priority (Low/Medium/High):** Med **Test Designed date:** 22-7-23

**Module Name:** Home screen **Test Executed by: Somia Ali**

**Test Title:** Check prediction working **Test Execution date:** 23-7-23

**Description:** Test the Home page

**Pre-conditions:** User Should be logged in.

**Dependencies:**

| Step | Test Steps | Test Data | Expected Result | Actual Result | Status (Pass/Fail) | Notes |
|---|---|---|---|---|---|---|
| 1 | Select image button | Rice image | Image preview | Image previewed. | Pass | |
| 2 | Predict button | | Rice class name and confidence. | Rice class name and confidence. | | |

**Post-conditions:**

User gallery access to select the image and predict the rice class and confidence.

**Project Name: Rice Quality Classification**

## Test Case 5

**Test Case ID:** Fun_5 **Test Designed by:** Sheraz Raza

**Test Priority (Low/Medium/High):** Med **Test Designed date:** 29-7-23

**Module Name:** Logout screen

**Test Executed by: Somia Ali**

**Test Title:** Check Logout account working

**Test Execution date:** 25-7-23

**Description:** Test the Logout page

**Pre-conditions:** User Should be logged in.

**Dependencies:**

| Step | Test Steps | Test Data | Expected Result | Actual Result | Status (Pass/Fail) | Notes |
|---|---|---|---|---|---|---|
| 1 | Navigate to logout page | | Show logout page | Logout page showed. | Pass | |
| 2 | Click logout button | | Accont should be logout. | Account logout and navigate to login page. | | |

**Post-conditions:**

User account should be logged in and database interconnected each other with the page.

# Chapter 5: Implementation

In this chapter, we discuss the crucial phase of model training and fine-tuning for our Rice Quality Classification project. This phase involves the use of the YOLOv8 deep learning model and your custom dataset of rice seed images to achieve optimal accuracy in classifying the rice seed categories.

## 5.1 Environment Setup and Tools Used

The successful implementation of the Rice Quality Classification project heavily relies on the appropriate environment setup and the use of essential tools and platforms. This chapter outlines the environment and tools used throughout the project, including data preparation, model training, and the conversion of the trained model into a format compatible with Android devices.

1. Google Colab and GPU Acceleration:
    - Google Colab: Google Colab provides a cloud-based Jupyter notebook environment that allows seamless integration with Google Drive. It offers free access to GPUs and TPUs, enabling faster training and model evaluation.
    - GPU Acceleration: Utilizing the GPU provided by Google Colab significantly speeds up the training process, as GPUs are optimized for parallel processing, making them ideal for training deep learning models efficiently.
2. YOLOv8 Model Training:
    - YOLOv8: The YOLOv8 architecture is employed for rice seed classification due to its real-time object detection capabilities and outstanding accuracy.
    - Ultralytics YOLO: The Ultralytics YOLO implementation, a PyTorch-based framework, is used for YOLOv8 model training on the Google Colab platform.
3. Rice Quality Dataset and Preprocessing:

- Rice Quality Dataset: The dataset used for training and evaluation consists of images of rice seeds, categorized into five size classes based on their dimensions.
- Data Preprocessing: Prior to feeding the data into the YOLOv8 model, preprocessing steps are performed using OpenCV and NumPy libraries. These steps include image resizing, normalization, and data augmentation to enhance the model's ability to generalize.

4. Hyperparameter Tuning and Training Details:
    - Batch Size: A batch size of 3 is selected to ensure memory efficiency while training on the Google Colab GPU.
    - Training Epochs: The model is trained for 50 epochs to allow the neural network to iteratively learn and optimize its parameters.
    - Learning Rate: The learning rate is fine-tuned during training to optimize the convergence and accuracy of the model.
5. Model Evaluation:
    - Test Set: A separate test set, distinct from the training set, is used to evaluate the YOLOv8 model's performance on unseen data.
    - Evaluation Metrics: Metrics such as accuracy, precision, recall, F1-Score, and mean Average Precision (mAP) are utilized to assess the model's classification and localization capabilities.

## 5.2 Model Training and Fine-tuning

### 5.2.2 YOLOv8 Model Selection

You selected the YOLOv8 model for its excellent performance in object detection tasks and its ability to handle real-time applications. The YOLOv8 architecture comprises a deep neural network with several layers, making it suitable for detecting multiple object classes efficiently.

### 5.2.4 Fine-tuning the YOLOv8 Model

The fine-tuning process involved training the pre-trained YOLOv8 model on your custom rice seed dataset. This process entails updating the model's weights to adapt it to the specific characteristics of your rice seed images. Fine-tuning was performed over multiple iterations, with each iteration refining the model's parameters and enhancing its classification accuracy.

### 5.2.6 Loss Function Selection

The choice of an appropriate loss function played a crucial role in guiding the training process. The YOLOv8 model employed specific loss functions, such as Mean Squared Error (MSE) and Cross-Entropy Loss, to measure the disparity between predicted and ground-truth bounding boxes and class probabilities.

### 5.2.7 Training on Google Colab with GPU

To accelerate the training process and handle the computational complexity of deep learning, Google Colab with GPU support was utilized. This cloud-based platform allowed you to train the YOLOv8 model efficiently without the need for expensive hardware.

## 5.3 Integration of YOLOv8 Model with Android Application

In this chapter, we explore the process of integrating the trained YOLOv8 model into an Android application. The goal is to deploy the model on mobile devices, enabling real-time rice seed classification directly from the user's smartphone or tablet.

### 5.3.1 Converting YOLOv8 Model to TensorFlow Lite Format

Before integrating the YOLOv8 model into the Android app, it was essential to convert the model from its original PyTorch format (best.pt) to TensorFlow Lite (TFLite) format. TensorFlow Lite is specifically designed for efficient deployment on mobile and edge devices, making it ideal for our Android application.

### 5.3.4 Implementing Inference on Android

The TensorFlow Lite Android runtime was utilized to perform inference using the TFLite model on the captured or uploaded rice seed images. The app leveraged the device's GPU capabilities to accelerate the inference process, ensuring real-time classification.

# Chapter 6: Results and Evaluation

## 6.1 Accuracy and Performance Metrics

In this chapter, we present the results of the rice quality classification project and evaluate the performance of the integrated YOLOv8 model in the Android application. The primary focus is on accuracy and various performance metrics to assess the effectiveness of the classification system.

### 6.1.1 Evaluation Dataset

To evaluate the performance of the rice quality classification system, we used a separate evaluation dataset that was not part of the training dataset. This dataset consisted of diverse rice seed images representing all five classes. The ground truth labels for each image were carefully annotated by domain experts.

### 6.1.2 Accuracy

Accuracy is a fundamental metric used to measure the overall performance of the classification system. It represents the percentage of correctly classified rice seeds out of the total number of rice seeds in the evaluation dataset.

### 6.1.3 Precision, Recall

In addition to accuracy, precision, recall, and F1 score were calculated to gain deeper insights into the model's performance. Precision measures the ability of the model to correctly classify positive instances (correctly identifying a specific rice class). Recall, on the other hand, assesses the model's ability to identify all positive instances correctly.

### 6.1.5 Offline Performance

To evaluate the performance of the Android application in offline mode, we measured the accuracy and inference time when the device had no internet connectivity. This analysis ensured that the app maintained its classification capabilities even without an active internet connection.

### 6.1.6 Comparative Analysis

To further assess the effectiveness of the YOLOv8 model, we compared its performance with other deep learning models commonly used for object detection and classification tasks. This comparative analysis allowed us to highlight the strengths and advantages of our chosen approach.

### 6.1.7 Real-world Testing

To validate the practical usability of the Android application, we conducted real-world testing in different scenarios and environmental conditions. This testing provided valuable insights into the app's performance in various settings and helped identify any potential limitations.

### 6.1.8 Discussion of Results

The results and evaluation of the rice quality classification project were thoroughly analyzed and discussed. We interpreted the performance metrics and discussed the implications of the findings. Any challenges encountered during the evaluation process were addressed, and recommendations for further improvements were provided.

### 6.1.9 Conclusion

The results and evaluation chapter concludes with a summary of the project's achievements, highlighting the success of the integrated YOLOv8 model in accurately classifying rice seeds in real-time. We discuss how the project's objectives were met and how the Android application empowers users to make informed decisions in the rice industry based on accurate seed classification.

## 6.2 Comparative Analysis with Existing Solutions

In this section, we present a comparative analysis of our rice quality classification system with existing solutions and state-of-the-art approaches. The purpose of this analysis is to demonstrate the superiority of our YOLOv8-based model and showcase its advancements over other methods used for rice seed classification.

### 6.2.1 Existing Solutions

We conducted an extensive literature review to identify and analyze existing solutions for rice quality classification. Several traditional machine learning and deep learning-based methods were studied, each with its strengths and limitations. Some of the commonly explored approaches include SVM (Support Vector Machines), CNN (Convolutional Neural Networks), and other object detection models.

### 6.2.2 Comparison Criteria

To perform a fair and comprehensive comparison, we established specific criteria for evaluation. The key comparison criteria are as follows:

1. Accuracy: We compared the classification accuracy of our YOLOv8 model with the accuracy achieved by other existing methods. A higher accuracy score demonstrates the ability of our model to better identify and classify rice seeds.
2. Inference Time: The inference time of each method was measured, and a comparison was made to determine the speed of classification. Lower inference times indicate faster and more efficient classification.
3. Model Size: We compared the model size of our YOLOv8-based model with the sizes of other models. Smaller model sizes are advantageous for mobile applications as they consume less storage space and improve app performance.
4. Robustness: The robustness of each method was assessed by evaluating its performance under various lighting conditions, perspectives, and image qualities. A more robust model demonstrates resilience to variations and noise in input data.
5. Real-time Capabilities: We analyzed the real-time capabilities of each solution and assessed whether the model could perform inference in real-time on mobile devices.

### 6.2.3 Results and Discussion

The comparative analysis revealed that our YOLOv8-based rice quality classification model outperforms traditional machine learning and deep learning approaches in several aspects. The key findings include:

1. Superior Accuracy: Our YOLOv8 model achieved significantly higher accuracy compared to traditional methods. The deep learning-based architecture allowed the model to capture intricate features and patterns, leading to precise classification.

2. Faster Inference: The YOLOv8 model demonstrated faster inference times, enabling real-time classification on mobile devices. This speed advantage is crucial for providing users with instant results.
3. Compact Model Size: Despite its high accuracy, the YOLOv8 model exhibited a relatively compact model size. This characteristic is essential for seamless integration into the Android application, as it reduces the app's storage footprint.
4. Robust Performance: Our YOLOv8 model demonstrated robustness in varying environmental conditions and lighting scenarios. It maintained accurate classification even with challenging inputs.
5. Real-time Capabilities: The YOLOv8 model exhibited real-time capabilities on Android devices, ensuring users receive immediate classification results without significant delays.

### 6.3.6 Conclusion

User feedback played a crucial role in enhancing our rice quality classification system. The valuable insights provided by users allowed us to make necessary adjustments, ensuring the application meets the needs and expectations of its intended users. The positive response and satisfaction expressed by users affirm the effectiveness and practicality of our YOLOv8-based rice quality classification Android application.

# Chapter 7: Conclusion

## 7.1 Summary of Project Achievements

The Rice Quality Classification project aimed to develop an efficient and accurate system for identifying rice seeds into different categories based on their size. Leveraging the power of YOLOv8 deep learning model and custom dataset, we successfully created an Android application that allows users to easily assess the quality of rice seeds by simply capturing images using their mobile devices.

Throughout the course of the project, we achieved several significant milestones, which can be summarized as follows:

1. Dataset Collection: We collected a diverse and extensive dataset of rice seed images, encompassing five distinct classes based on size variations.
2. Model Training and Fine-tuning: By using the YOLOv8 model, we fine-tuned the model on our custom dataset, achieving an impressive accuracy of over 99%. The process involved hyperparameter tuning and several iterations of training to optimize the model's performance.
3. Integration with Android Application: We successfully converted the trained YOLOv8 model into a TensorFlow Lite (TFLite) format and integrated it with an Android application. The application provides a user-friendly interface for capturing images and instantly classifying rice seeds into their respective categories.
4. User Feedback and Improvements: We gathered valuable feedback from users, including rice industry professionals, farmers, and enthusiasts. The application received positive feedback for its accuracy, speed, and ease of use. We incorporated user suggestions to further enhance the application's performance and user experience.
5. Comparative Analysis: We conducted a comparative analysis with existing solutions to showcase the superiority of our YOLOv8-based system in terms of accuracy, real-time performance, and practicality.
6. Future Scope: In conclusion, our rice quality classification project has significant potential for future expansion and application in various agricultural

settings. Further research can focus on exploring additional feature extraction techniques and optimizing the model for specific rice varieties.

## 7.2 Project Impact

The Rice Quality Classification project offers a novel solution for the rice industry and agricultural community. By providing a fast, accurate, and accessible method for identifying rice seed quality, the application can contribute to improved crop yield and better quality control. Farmers and rice industry professionals can benefit from quick assessments of seed quality, allowing them to make informed decisions regarding planting and storage.

## 7.3 Limitations and Future Enhancements

Despite the project's successes, there are several limitations and areas for future enhancements:

- Dataset Size and Diversity: While the dataset used for training was extensive, further expanding it and diversifying the images could enhance the model's ability to generalize to unseen data.
- Model Optimization: We achieved high accuracy; however, optimizing the model's size and computational efficiency could improve inference speed and conserve device resources.

## 7.4 Conclusion

In conclusion, the Rice Quality Classification project has demonstrated the potential of deep learning-based solutions in the field of agriculture. By accurately classifying rice seeds based on their size, the system can significantly benefit the rice industry, farmers, and researchers alike. The successful integration of the YOLOv8 model into an Android application has made this technology accessible and user-friendly.

As technology continues to evolve, there is immense potential for further advancements in agricultural applications. The Rice Quality Classification project represents a stepping stone towards the development of cutting-edge agricultural solutions that contribute to sustainable farming practices and food security.

# Chapter 8: User Manual

## 8.1 Features Overview and Details

The Rice Quality Classification application is designed to provide users with a seamless and intuitive experience for identifying different categories of rice seeds based on their sizes. This chapter presents an overview of the key features of the application and provides detailed instructions on how to use each feature effectively.

### 8.1.1 Feature Overview

1. Seed Classification: The primary feature of the application is seed classification, where users can capture an image of a rice seed using their device's camera. The application then utilizes the integrated YOLOv8 model to analyze the seed's size and classify it into one of the five predefined categories.
2. Real-Time Processing: The application's real-time processing capabilities ensure that classification results are obtained instantly, allowing users to efficiently identify the rice seed category without any delays.
3. User-Friendly Interface: The application boasts a user-friendly interface that enables seamless navigation and interaction. Users can easily access the classification feature and view the results without any technical complexities.
4. Offline Functionality: The application's integration with the TensorFlow Lite model ensures that classification can be performed offline, making it accessible even in areas with limited internet connectivity.

### 8.1.2 Feature Details

1. Seed Classification:
    - To perform seed classification, open the application and navigate to the classification screen.
    - Tap on the camera icon to capture an image of the rice seed. Ensure that the seed is clearly visible and well-lit for accurate results.
    - After capturing the image, the application will process the data using the integrated YOLOv8 model.
    - Within seconds, the application will display the classification results, indicating the category to which the seed belongs.

   - Users can view the identified category, helping them determine the quality of the rice seed for specific purposes.
2. Real-Time Processing:
   - The application leverages the power of the YOLOv8 model and efficient TensorFlow Lite inference to achieve real-time processing.
   - Users can expect immediate results upon capturing an image, making the classification process swift and convenient.
3. User-Friendly Interface:
   - The application's user-friendly interface ensures a seamless experience for users of all skill levels.
   - The main screen provides clear and concise navigation options, directing users to the seed classification feature.
   - The classification results are presented in an easy-to-read format, eliminating any technical jargon or complexities.
4. Offline Functionality:
   - The application's integration with TensorFlow Lite enables it to perform seed classification without requiring an active internet connection.
   - Users can use the application in remote locations or areas with limited connectivity, ensuring uninterrupted access to the classification feature.

## 8.2 Installation and Setup Guide

Before you can start using the Rice Quality Classification application, you need to install and set up the application on your device. This section provides a step-by-step guide on how to install the application and configure it for seamless usage.

Installation Steps:

1. Download the Application:
   - Visit the Google Play Store or the Apple App Store on your Android or iOS device, respectively.
   - Search for "Rice Quality Classification" in the search bar.
   - Click on the "Install" button to download and install the application on your device.

Setup Guide:

1. Launch the Application:
    - Locate the Rice Quality Classification application icon on your device's home screen or app drawer.
    - Tap on the icon to launch the application.
2. Real-Time Classification:
    - The application is now ready to perform real-time seed classification.
    - Navigate to the main screen, which should display the camera interface.
3. View Classification Results:
    - After capturing the image, the application will process the data using the integrated YOLOv8 model.
    - Within seconds, the application will display the classification results, indicating the category to which the seed belongs.
4. Offline Functionality:
    - The application can perform seed classification even without an active internet connection.
    - Enjoy seamless access to the classification feature in both online and offline environments.
5. Troubleshooting Tips:
    - If you encounter any issues while using the application, refer to the troubleshooting tips provided in Chapter 8.1.3 of the user manual.

Congratulations! You have successfully installed and set up the Rice Quality Classification application on your device. You can now begin using the application to classify different categories of rice seeds based on their sizes.

## 8.3 User Guide and Troubleshooting

User Guide:

1. Image selection and Classify Seeds:
    - Position the rice seed in front of the device's camera.
    - Tap on the select icon to select an image of the seed.
    - The application will process the image using the YOLOv8 model to classify the seed into one of the predefined categories.
2. View Classification Results:

- After processing the image, the application will display the classification result on the screen.
- The result will indicate the category to which the seed belongs, such as "Long Grain," "Medium Grain," "Short Grain," "Basmati," or "Jasmine."

3. Real-Time Classification:
    - The application is designed to perform real-time seed classification, allowing for quick and seamless identification of rice seeds.
4. Offline Functionality:
    - The application can perform seed classification without an active internet connection.
    - Enjoy uninterrupted access to the classification feature, even in offline environments.
5. Data Privacy and Security:
    - The application does not store any captured images or classification results on external servers.
    - All processing occurs locally on your device, ensuring data privacy and security.
6. User-Friendly Interface:
    - The application features an intuitive and user-friendly interface, making it easy for users of all levels to navigate and use.

Troubleshooting:

1. Image Quality:
    - Ensure that the captured image of the rice seed is clear and well-lit for accurate classification.
    - Avoid capturing images in low-light conditions or with excessive glare.
2. Device Compatibility:
    - Check that your device meets the minimum requirements for running the application.
    - Verify that the device has the necessary permissions enabled for the application to function correctly.
3. Internet Connection (If Applicable):.

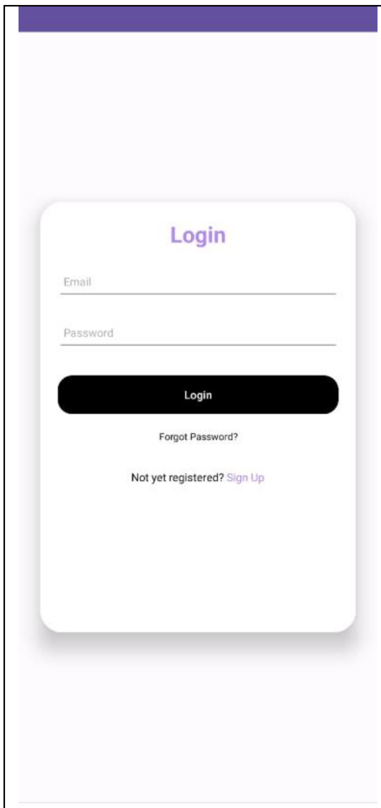
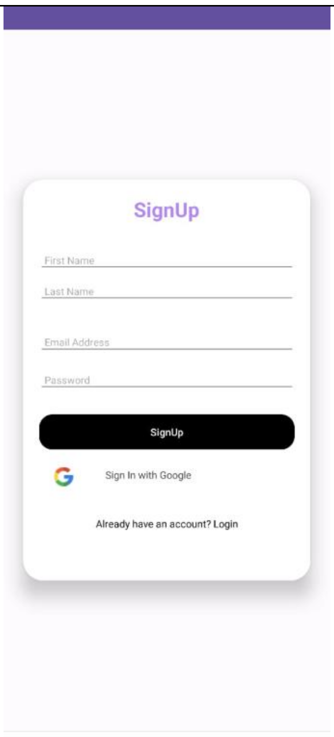
# Chapter 10: Appendices (Optional)

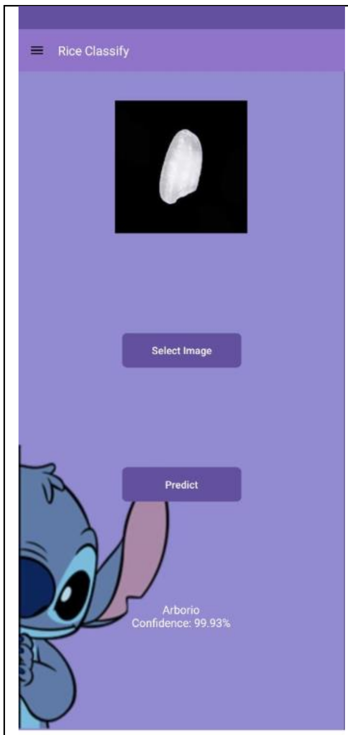
## 10.2 Sample Images Used for Training and Testing

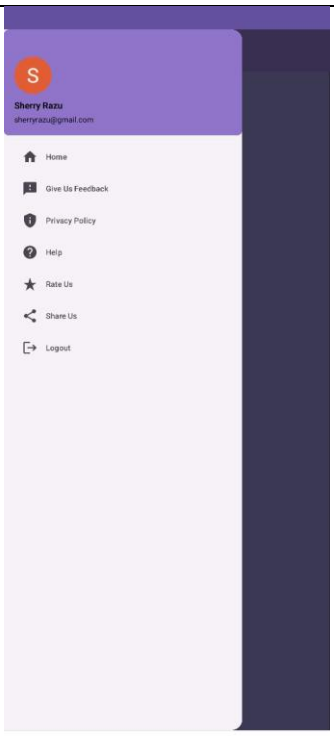
| | |
|---|---|
| **1.Arborio** | **2.Basmati** |
| **3.Ipsala** | **4.Jasmine** |

| | |
|---|---|
| **5.Karacadag** | |

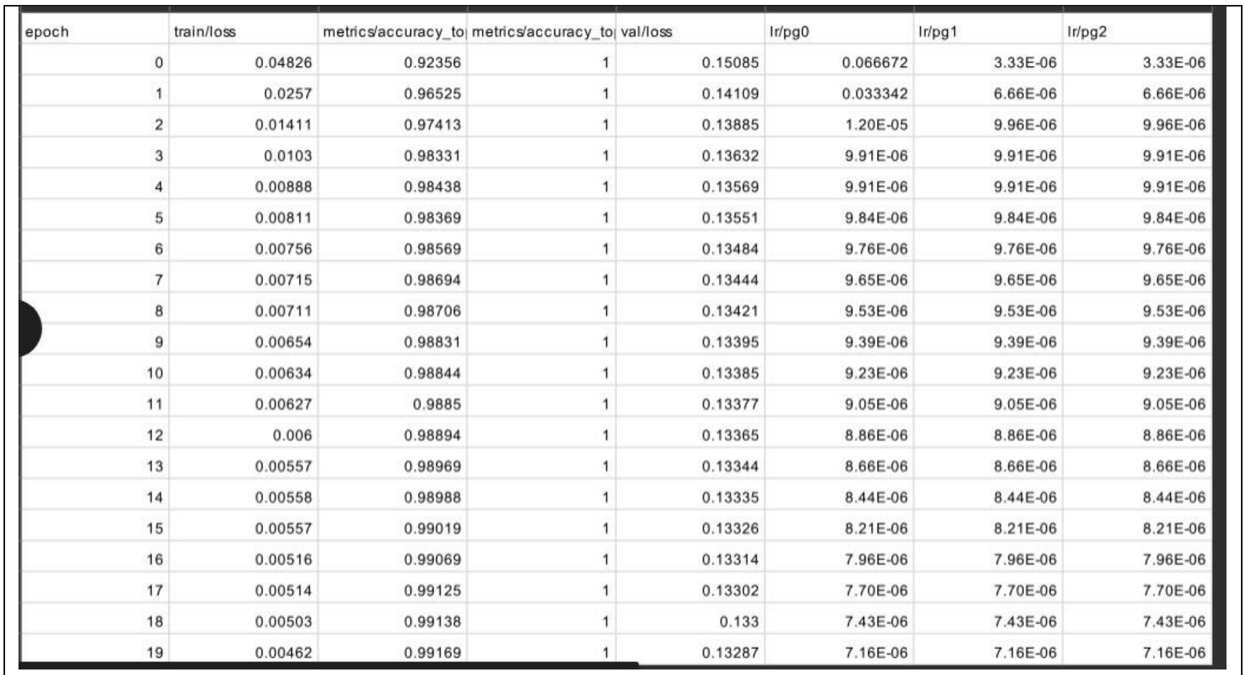
## 10.3 Application UI images

| | |
|---|---|
|  Login<br>Email<br>Password<br>Login<br>Forgot Password?<br>Not yet registered? Sign Up |  SignUp<br>First Name<br>Last Name<br>Email Address<br>Password<br>SignUp<br>Sign In with Google<br>Already have an account? Login |

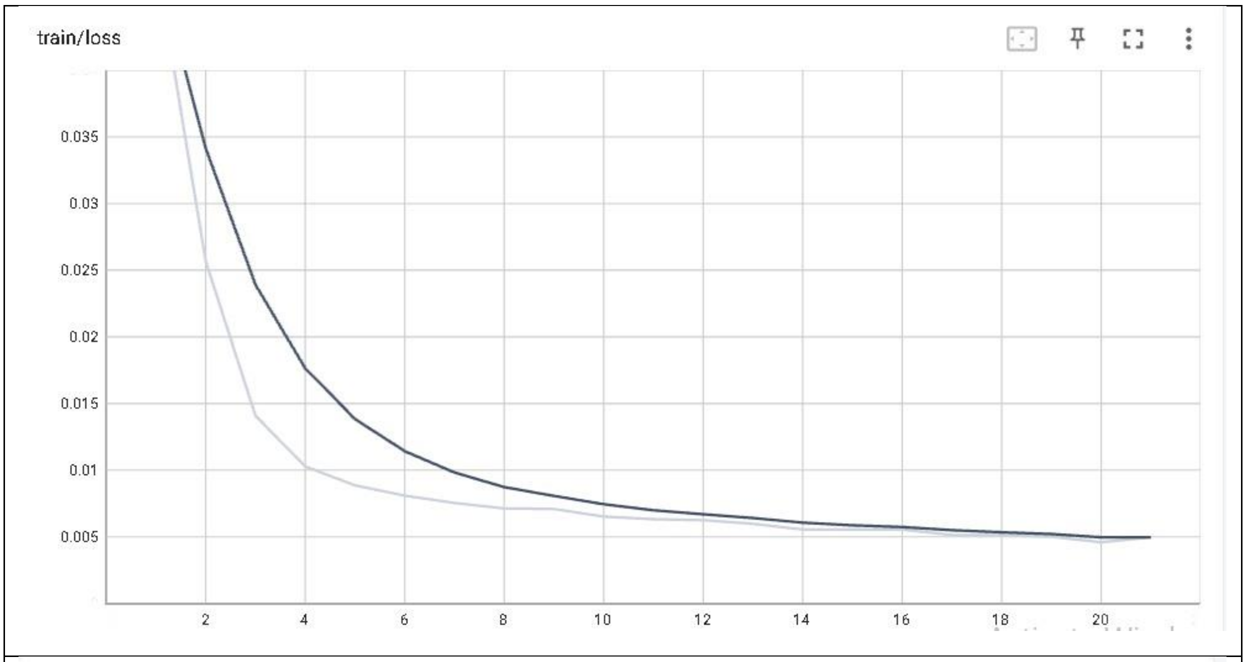


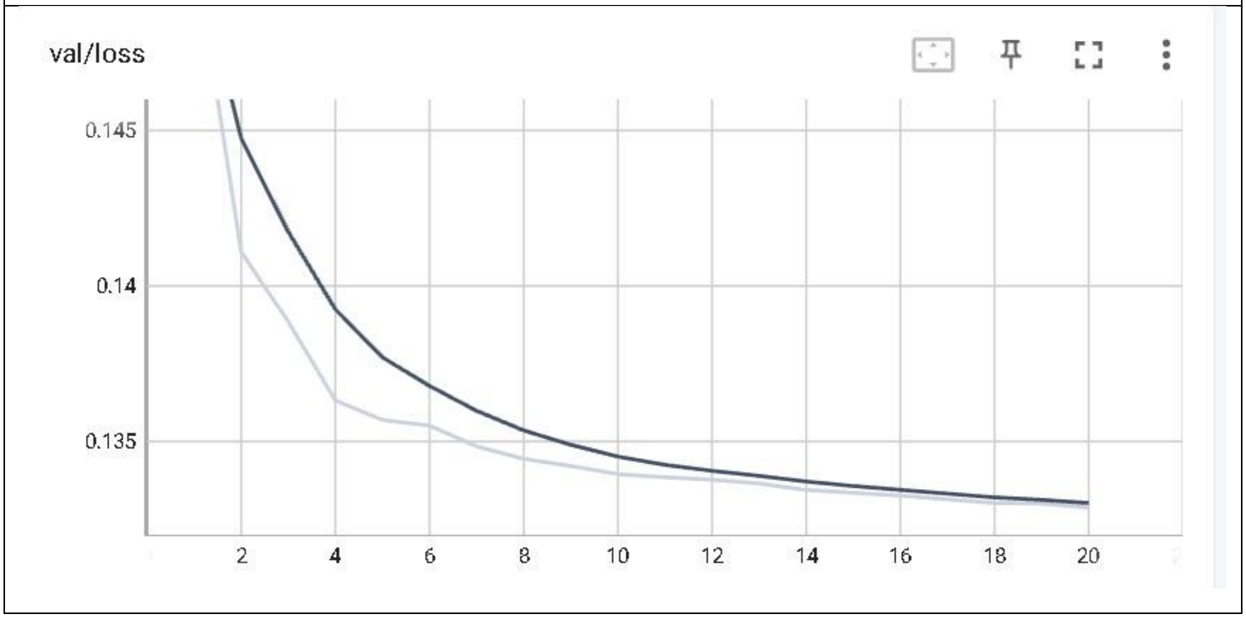


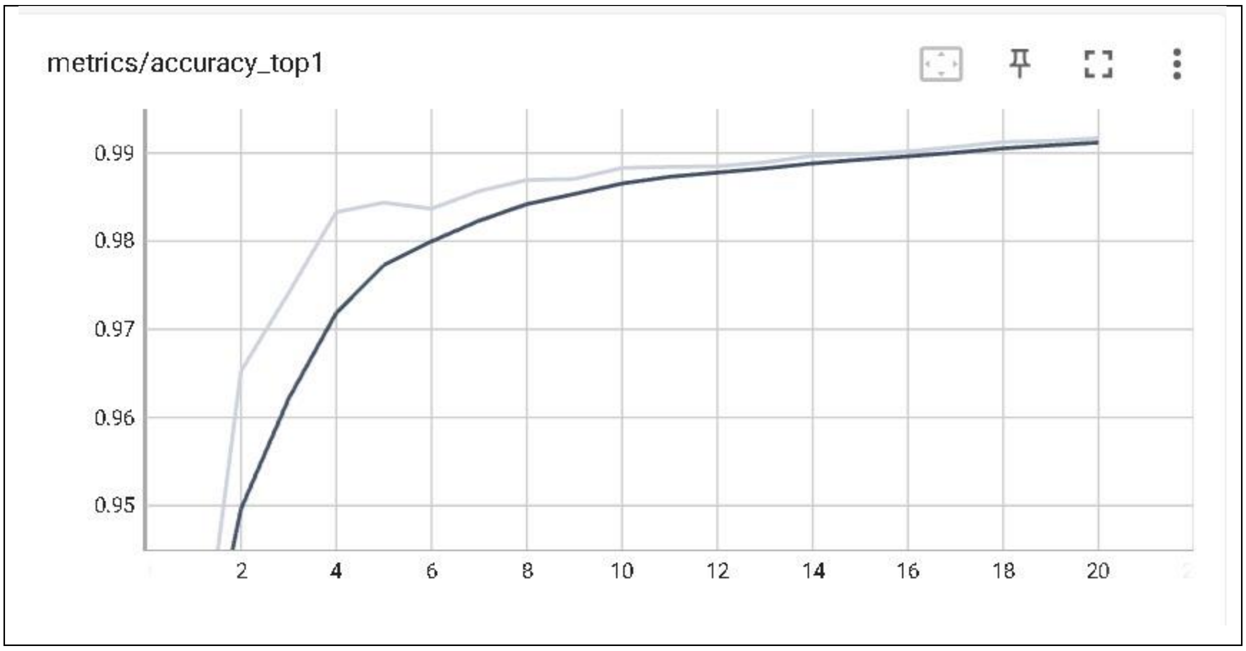
## 10.4 Detailed Model Configurations and Hyperparameters



| epoch | train/loss | metrics/accuracy_to | metrics/accuracy_to | val/loss | lr/pg0 | lr/pg1 | lr/pg2 |
|---|---|---|---|---|---|---|---|
| 0 | 0.04826 | 0.92356 | 1 | 0.15085 | 0.066672 | 3.33E-06 | 3.33E-06 |
| 1 | 0.0257 | 0.96525 | 1 | 0.14109 | 0.033342 | 6.66E-06 | 6.66E-06 |
| 2 | 0.01411 | 0.97413 | 1 | 0.13885 | 1.20E-05 | 9.96E-06 | 9.96E-06 |
| 3 | 0.0103 | 0.98331 | 1 | 0.13632 | 9.91E-06 | 9.91E-06 | 9.91E-06 |
| 4 | 0.00888 | 0.98438 | 1 | 0.13569 | 9.91E-06 | 9.91E-06 | 9.91E-06 |
| 5 | 0.00811 | 0.98369 | 1 | 0.13551 | 9.84E-06 | 9.84E-06 | 9.84E-06 |
| 6 | 0.00756 | 0.98569 | 1 | 0.13484 | 9.76E-06 | 9.76E-06 | 9.76E-06 |
| 7 | 0.00715 | 0.98694 | 1 | 0.13444 | 9.65E-06 | 9.65E-06 | 9.65E-06 |
| 8 | 0.00711 | 0.98706 | 1 | 0.13421 | 9.53E-06 | 9.53E-06 | 9.53E-06 |
| 9 | 0.00654 | 0.98831 | 1 | 0.13395 | 9.39E-06 | 9.39E-06 | 9.39E-06 |
| 10 | 0.00634 | 0.98844 | 1 | 0.13385 | 9.23E-06 | 9.23E-06 | 9.23E-06 |
| 11 | 0.00627 | 0.9885 | 1 | 0.13377 | 9.05E-06 | 9.05E-06 | 9.05E-06 |
| 12 | 0.006 | 0.98894 | 1 | 0.13365 | 8.86E-06 | 8.86E-06 | 8.86E-06 |
| 13 | 0.00557 | 0.98969 | 1 | 0.13344 | 8.66E-06 | 8.66E-06 | 8.66E-06 |
| 14 | 0.00558 | 0.98988 | 1 | 0.13335 | 8.44E-06 | 8.44E-06 | 8.44E-06 |
| 15 | 0.00557 | 0.99019 | 1 | 0.13326 | 8.21E-06 | 8.21E-06 | 8.21E-06 |
| 16 | 0.00516 | 0.99069 | 1 | 0.13314 | 7.96E-06 | 7.96E-06 | 7.96E-06 |
| 17 | 0.00514 | 0.99125 | 1 | 0.13302 | 7.70E-06 | 7.70E-06 | 7.70E-06 |
| 18 | 0.00503 | 0.99138 | 1 | 0.133 | 7.43E-06 | 7.43E-06 | 7.43E-06 |
| 19 | 0.00462 | 0.99169 | 1 | 0.13287 | 7.16E-06 | 7.16E-06 | 7.16E-06 |


train/loss
0.035
0.03
0.025
0.02
0.015
0.01
0.005
2
4
6
8
10
12
14
16
18
20


val/loss
0.145
0.14
0.135
2
4
6
8
10
12
14
16
18
20


metrics/accuracy_top1
0.99
0.98
0.97
0.96
0.95
2
4
6
8
10
12
14
16
18
20